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# **6 Measurement and Earthwork Calculations**

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**Contract Quality Payment**

**Measured Quantity Payment**

**Measurement and Earthwork Calculations**

**Cross Sections**

**Volumes**

# ***CHAPTER SIX: MEASUREMENTS AND EARTHWORK CALCULATIONS***

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An important part of the discussion of earthwork is the determination of pay quantities. In this section the following items are discussed:

- 1) Contract quantity payment
  - 2) Measured quantity to include cross sections, computations of volumes, and terms.
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## **CONTRACT QUANTITY PAYMENT**

According to the Standard Specifications, the quantities of excavation shown in the contract are required to be paid, unless either the Contractor or INDOT disagrees. When paying plan quantities for excavation, the following procedures are to be followed:

- 1) New original cross-sections are to be taken at 500 ft intervals and plotted to check the accuracy of the original sections.
- 2) Final cross-sections are to be taken at 500 ft intervals. Cross-sections are required to be complete sections in cuts and from the shoulder break to the right-of-way in fills. These final sections indicate substantial conformance with the planned cut slopes and ditches and are used to determine if earthwork deductions are required.
- 3) Spot checks are made of the cross-section areas shown in the plans. The number of spot checks are required to average one for each 2000 ft with the locations concentrated in areas of the major excavation. Additional area checks are made to determine whether the plan quantity needs to be adjusted for areas varying more than 10% from the area shown on the plans. If the average deviation of all the areas checked varies from the planned areas at the corresponding locations by more than 2%, a more detailed check is required on those areas or balances showing the highest deviation.

- 4) The computation of the volume from the planned areas of one balance are required to be checked. In general, this balance should be the largest balance in the contract. Any other questionable balances are required to be checked for volume computations.
- 5) Any other pertinent facts which would justify using plan quantity or indicating the need for adjustments is required to be considered.

## **MEASURED QUANTITY PAYMENT**

Where measured quantities are specified or found necessary by the check of plan quantities, the excavated quantities in each balance will be computed on Form IC 401. If "excess cut" or "waste" deductions, as described later, are applicable to the roadway excavation, they are deducted from the balance totals.

## **MEASUREMENT AND EARTHWORK CALCULATIONS**

Payment for grade construction is usually based on a bid price per yd<sup>3</sup> for excavation measured in-place as computed from survey notes. The unit price generally includes the following:

- 1) Hauling excavated material (cut) from within the limits of the roadway or bringing in other material from outside areas(borrow)
- 2) Building the embankments (fill) to specified form
- 3) Disposing of surplus material (waste)
- 4) Performing such operations as forming earth shoulders, trimming slopes, and preparing the subgrade for pavement

## **CROSS SECTIONS**

The determination of earthwork quantities is based upon field cross-sections taken in a specified manner before and after excavation. Cross-sections are vertical profiles taken at right angles to the survey centerline. Every section is an area formed by the subgrade, the sideslopes, and the original ground surface.

## VOLUMES

Volumes are computed from cross-section measurements by the average end area method.

$$\text{Volume (english) (yd}^3\text{)} = [L \times \frac{(A_1 + A_2)}{(2 \times 27)}]$$

L is in feet.

A<sub>1</sub> and A<sub>2</sub> are in square feet.

$$\text{Volume (metric) (m}^3\text{)} = [L \times \frac{(A_1 + A_2)}{2}]$$

L is in meters.

A<sub>1</sub> and A<sub>2</sub> are in square meters.

These formulas are used to compute earthwork quantities because the specifications require this calculation. All the plans and bidding for the project have been completed using this method.

The formula for average end areas is accurate only when the end areas are equal. For other cases, the formula generally gives volumes slightly larger than their true values. If applied to a pyramid, for example, the error would be the maximum and would be equal to 50% of the correct volume. In practice, however, the total error over the long run is seldom more than 2%.

Also, where not practical to measure material by the cross-section method due to erratic location of isolated deposits, acceptable methods involving three dimensional measurements may be used to measure material in the original position. Equations for these measurements are:

$$\text{Volume (yd}^3\text{)} = \frac{(\text{Length} \times \text{Width} \times \text{Depth})}{27}$$

$$\text{Volume (m}^3\text{)} = \text{Length} \times \text{Width} \times \text{Depth}$$

Earthwork may also be measured on a linear basis. For linear grading items in a contract, the measurement for payment is based on the actual length of roadway mileage constructed. This includes all classes of excavation on both sides of the roadway.

Excavation items may also be measured on a weight basis as indicated in Section **203.27**.

Embankment fills are not paid for directly. The cost is to be included in the other pay items of the contract. In certain contracts, fills are paid for directly.

Borrow is measured and paid for by the yd<sup>3</sup>. In most cases, borrow is cross-sectioned in the original position of the borrow before excavation begins and after excavation is completed. The volumes are computed by the average end area method.

Excavation may also be measured on a lump sum basis. When this occurs, no individual measurements are required.

There are many other special cases for different types of measurements and classes of excavation which may be encountered on a construction contract. The plans, special provisions, Specifications, General Instructions To Field Employees, and the PE/PS should be consulted when starting an operation on a contract.